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FRET-based acrylic nanoparticles with dual-color photoswitchable properties in DU145 human prostate cancer cell line labeling

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Dual-color photoswitchable fluorescent polymer nanoparticles have emerged as an important type of cell detectors. Here, dual-color acrylic nanoparticles containing spiropyran and azo-carbazole derivatives with remarkable photostability and photoreversibility were employed. These prominent properties were attributed to the covalent bonding between the incorporated chromophores and the polymeric matrix and provided efficient fluorescence resonance energy transfer phenomenon. The obtained nanoparticles were purified after dialysis and delivered into DU145 cancer cells. Trypan blue dye exclusion assays showed that these nanoparticles were biocompatible with no toxicity to the cells. Fluorescence microscopy images demonstrated that the prostate cancer cells containing nanoparticles exhibited excellent cell uptake with green and red fluorescence emissions after primary excitation at 410 nm and subsequent irradiation at 365 nm, respectively, depicting their dual-color characteristics.

1. Introduction

Dual-color photoswitchable fluorescent (DCPF) nanoparticles represent a new class of materials for exploitation of fluorescent technique in biological [1–3]. These fluorescent nanoparticles, based on fluorescence resonance energy transfer (FRET) phenomenon, have received many attentions because of some advantages over conventional fluorescent dyes as distinguishing fake positive signals by aberrant fluorescent biomolecules and targeted locations [4,5]. Hence, they have shown versatile applications in optically addressable devices [2], drug delivery [6], cell labeling and imaging [2,7,8], bioimaging and rewriteable pattering [9,10], sensing tools and optical switching [11–13].

Photoswitchable fluorescence labeling of cells and biomolecules has become one of the most important techniques to study molecular processes within biological systems. Utilization of the traditional fluorescence technologies have many restrictions practically, like autofluorescence or intrinsic false positive signals of biological systems that can generate interferences and consequently obscure required signals [4,5,7]. Photoswitchable polymer nanoparticles that modulate fluorescence with external light stimulation will be a good resolution here. In fact, reversible fluorescence modulation switches fluorophores “on” and “off” and would be exploited to distinguish fake signals of background from original ones [2]. In many researches, the fluorescent dye is doped or physically adsorbed into a polymeric matrix that raise potential dye leakage and dye aggregation, and consequently produces cytotoxicity for cells and blinking in long time. These represent additional drawbacks for their advanced biological, in-vitro and in-vivo applications [7,14]. To address these problems, dual-color photoswitchable fluorescent nanoparticle with covalent bonding between chromophores and polymeric matrix demonstrate several advantages over the traditional doped ones (without any chemical linkage). These advantages will donate remarkably high brightness, extraordinary photostability, photoreversibility, high fatigue resistance and biocompatibility with potential application in living cells [15].

Dual-color polymer nanoparticles based on FRET consist of both donor and acceptor moieties. Photochromic compounds like spiropyrans are of high interest and act as acceptor chromophores [16,17]. Spiropyran derivatives respond to incident light and involve in a photoinduced ring-opening reaction that spiro (SP) form changes to merocyanine (MC) form with different spectroscopic properties [18–20]. Merocyanin isomer of spiropyran can receive energy from a fluorescent dye through fluorescence resonance energy transfer. Fluorescent molecules such as azo-carbazole ethyl

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